Time in Open Source GIS Web-based Visualizations

N. Lynnae Sutton
Jackie Olson

AGI Community
September 18, 2013

Project Goals

- Develop and evaluate mapping techniques for spatio-temporal data using open-source GIS, graphic, and processing software
- Due to breath of analysis techniques for spatio-temporal data analysis and database storage issues, we focused on techniques to address visualization and secondarily data manipulation.
- We also developed a framework for categorizing spatio-temporal mapping and visualization types.

Spatio-Temporal Mapping

- Spatio-temporal mapping is the representation of changes in geographical phenomena through time
- Spatial change components include: shape, location, presence and size.
- Temporal change components include: states, rate, duration and intervals.
- Attributes include qualitative and quantitative descriptors.

Spatial Change Terminology

- Spatial
  - Presence – presence or absence of a spatial feature
  - Shape, location and size of spatial features

Temporal Change Terminology

- Temporal
  - State – Spatial and attribute features at a moment in time
  - Rate – Speed of movement or speed of change of spatial phenomena
  - Duration – Length of time of a condition of spatial feature and attributes, has a beginning and end
  - Interval – An event or duration repeating in patterns

Visualization

- Visualization methods are explored:
- Types of image presentation of change:
  - Static maps (single and multiple states)
  - Dynamic display
    - Animation (movie)
    - Interactive maps (primarily web in our evaluation)
- Data representation:
  - Symbolic temporal representation (symbol represents the time change)

Visualization

- GIS software have plugins for temporal animation and interactivity
- Supporting software including GIS, graphic and animation software will frequently be needed to make the final visualization

Open Source Software / Data

Components:

- OpenGeo Community Suite
- PostGRES
- GeoServer
- PostgreSQL/PostGIS
- Kartograph.js.
- Weave
- Leaflet and OpenPlans Leaflet Animated Marker
- timemap.js
- jQuery Geo and Slider
- Dojo.js and Dojo Slider
- Quantum GIS and Time Manager
- OpenLayers Track
- I2maps
- WMS
- D3
- Pmapper
- PieCharts
- UNM MapServer
- Heron Map Client
- GeoEXT
- Inkscape
- GIMP
- OpenOffice Calc
- Vim
- Notepad++
- UltraEdit
- 7-Zip
- IrfanView
- VirtualDub
- Google Physical and Terrain
- Mapquest OSM
- Stamen Watercolor

Map Types

- There are many organizations of map types. For this project we focused on the visualization aspect and identified 3 broad types: **static, animation and interactive**.
- Time data is frequently collected and displayed as individual states, no matter how infinitely subdivided.
- Some data are durations with beginning and ending dates.

Spatial-temporal mapping framework

Presentation	Spatial	Temporal	Attribute
Static	Size/shape	State	Qualitative
Animation	Location	Rate	Quantitative
Interactive	Presence/ absence	Duration	
		Interval	

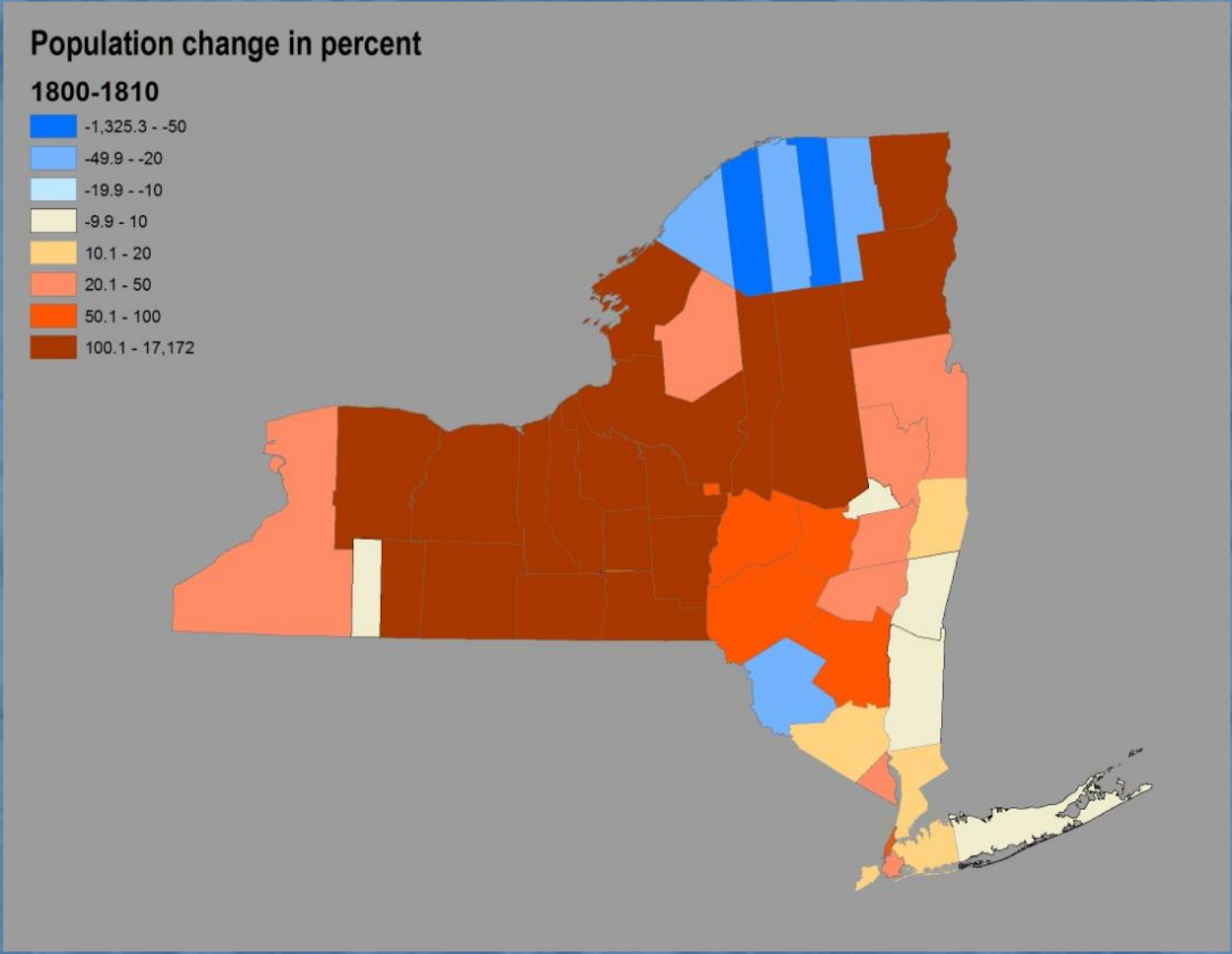
Static Maps

- Presentation is limited to a single image where time's passage is represented by symbols.
- They may be hard-copy or digital, single or multiple 'pages'.
- Two visualization options are:
  - to show change from one state to another by the symbol design (census percent change)
  - present two or more static maps with each showing a single state.

Static, single image – two states change - quantitative symbology

- Population density change for New York State from 1800 to 1810.
- Shapefiles and data from National Historical GIS (US Census figures).
- Layout and export of map image from Q-GIS
- Symbol color represents change in data value between two states: two decadal censuses.
- Advantage: user can see the change that occurred between two states.
- Disadvantage: requires interpretation, user does not see the original two states (unless three maps are presented).

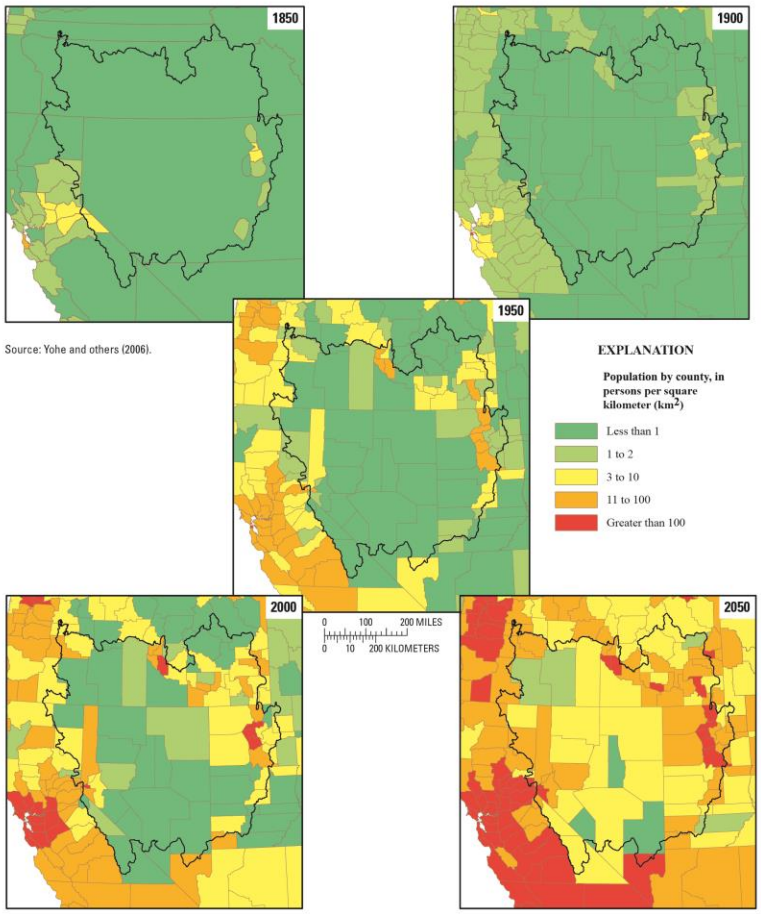
New York 1800-1810



Static multiple – shape change – multiple states – quantitative

- Population change at 50 year intervals.
- Time is represented by sequential static images.
- Qgis and Gimp for final layout.
- Advantage: Good for printed publications.
- Limitation: Dependant upon the viewer's ability to compare images to identify changes that have occurred.
- Example from USGS SIR 2010-5133. Data from Minnesota Population Center and US Census Bureau.

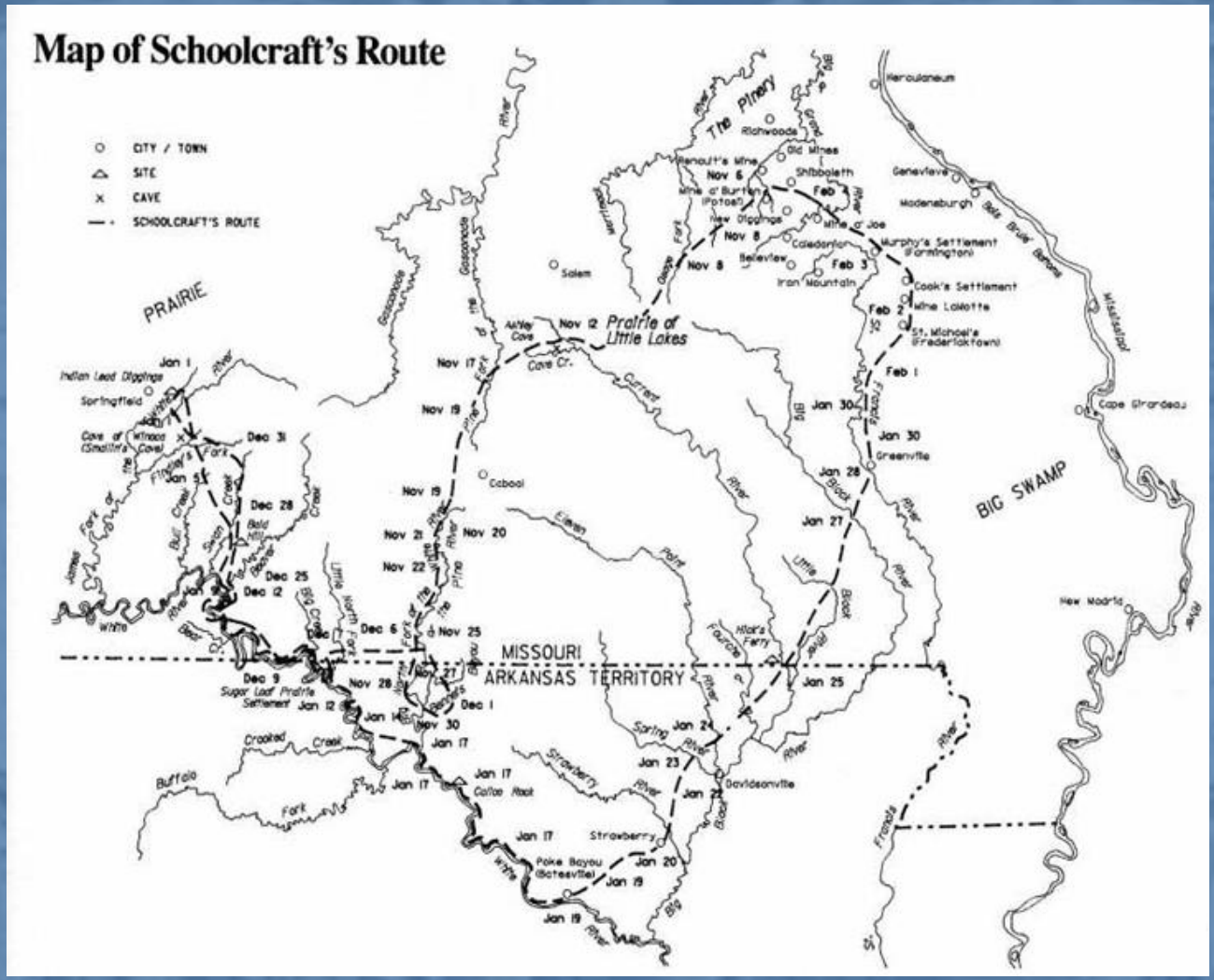
Great Basin Population Change



Static, single – location change – multiple temporal states

- A map of explorer Henry Rowe Schoolcraft's route.
- Example of a static track map. Time is indicated by labels at points along the route. Other information is provided about the journey.
- Advantage: Good for printed publication.
- Limitation: Viewer interprets time and location change by text labels showing date
- Source: http://www.smallincave.com/Historypage_smallincave.html

Explorer H. R. Schoolcraft's Route



Static single – size/shape, location, presence changes – multiple states – qualitative and quantitative changes

- Land cover change from satellite data
- Remote sensing software – (ie.GRASS)
- Advantages: depending on method (i.e. difference image, CVA) shows change in land cover, amount of land cover change and direction of change

Limitations:

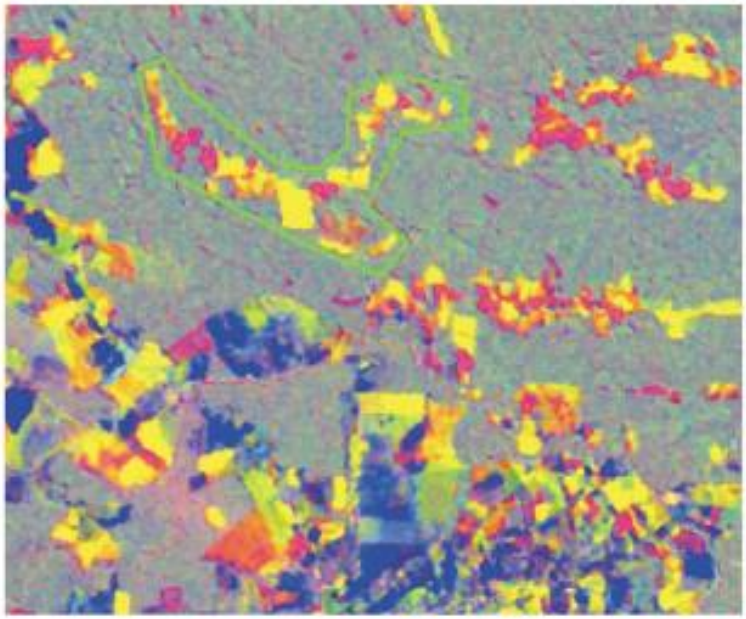
  - Spatial, spectral resolution and expert knowledge
  - Cause of change unknown

- Source: Dengsheng, L.; Batistella, M.; Moran, E. 2004. Multitemporal spectral mixture analysis for Amazonian land-cover change detection. Canadian Journal of Remote Sensing 30(1):87-100.

1994 TM image

1998 TM image

TM image color composites (Band TM 4, 5,3 /R, G, B)



1994-1998 color composite using fraction differencing images

(Differencing images shade, green vegetation, and soil fractionas, respectively, as R, G. B)

Animation Maps

- The second type is animation maps which present sequential static images in a structured time frame. A movie is a good example.
- The designer sets the content and the frame rate. The viewer only controls the start, stop, and sometimes pause of the flow. The sequence may be looped (repeating until a control ends the play). They are unidirectional.
- All information is presented on the frames, no querying beyond the presentation is possible.

Animation – location change – multiple states – quantitative change

- Track map of voyage of HMS Beagle. Color of symbol is coded for air temperature sampled that day.
- Data processed in Excel and Q-GIS. Background is Google Maps. Animation frames from Q-GIS plugin Time Manager. AVI of frames made in VirtualDub.
- Data from Darwin Online http://darwin-online.org.uk/ Some locations derived from Google Maps via http://fpc.org/latlong.html.

Animation – location change – multiple states – quantitative change

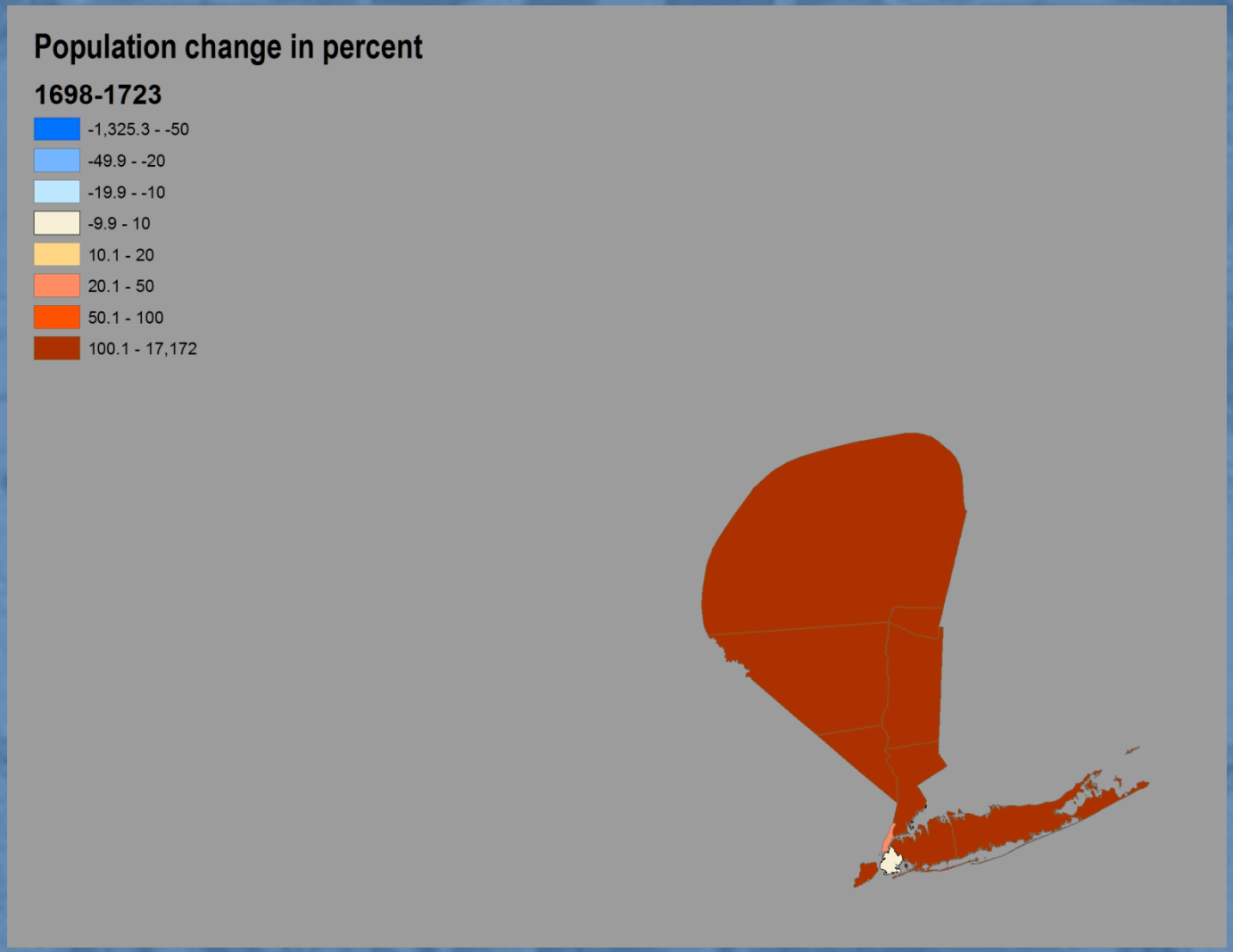
- Darwin's HMS Beagle route map showing air temperature
- Advantage: Great visualization for vector data within QGIS for data after 1970
- Limitation: Database requirements for data formatting were incompatible with data for the example.
- These problems occurred in both GIS animation and data preparation software.
  - Dates in Excel are limited to 1900 and after, all dates were converted from 19th c. to 20th c. (i.e. 1831 to 1931) to access the date as a time stamp.
  - Dates in Time Manager are limited to 1970 and after; all values were shifted 40 years to make the animation.

HMS Beagle

Animation – size/shape and location change – multiple states – quantitative change

- Population density change New York counties, 1623-2010.
- Data managed in Excel, Q-GIS (originally in ArcGIS). Exported frames converted to AVI in VirtualDub.
- Advantage: the users can see the changes over time in size and shape easily. The quantity change is harder to see, requires interpretation.
- Limitations: Areal unit change problems. Attribute value associated with original areal unit (county boundaries). Areal units change over time which requires a method (i.e. weighted average) to estimate the changes.
- Source of shapefiles is National Historical GIS, US Census Bureau; population data before 1790 from Purvis, T.L., *Colonial America To 1763.*

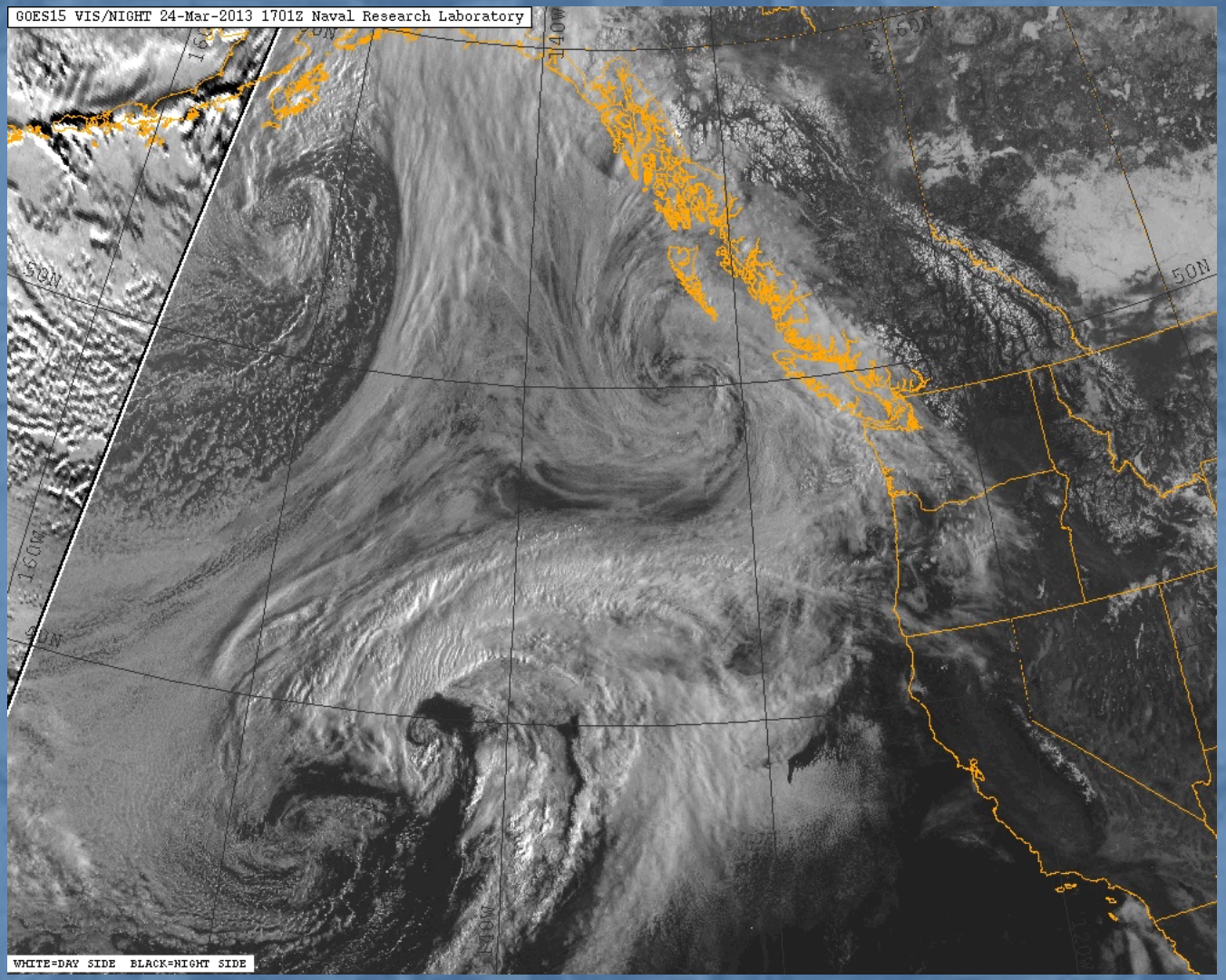
New York Population Density Change



Animation – size/shape, location change – multiple states

- GOES Satellite images of Northwest North America
- Example of geographic phenomenon that is not georeferenced for use in a GIS, but can still demonstrate change over time.
- Advantage: Easy to interpret for the user.
- Limitation: Not a database, simply a movie showing the change
- Images from NASA, frames compiled in VirtualDub.

Northwest Weather



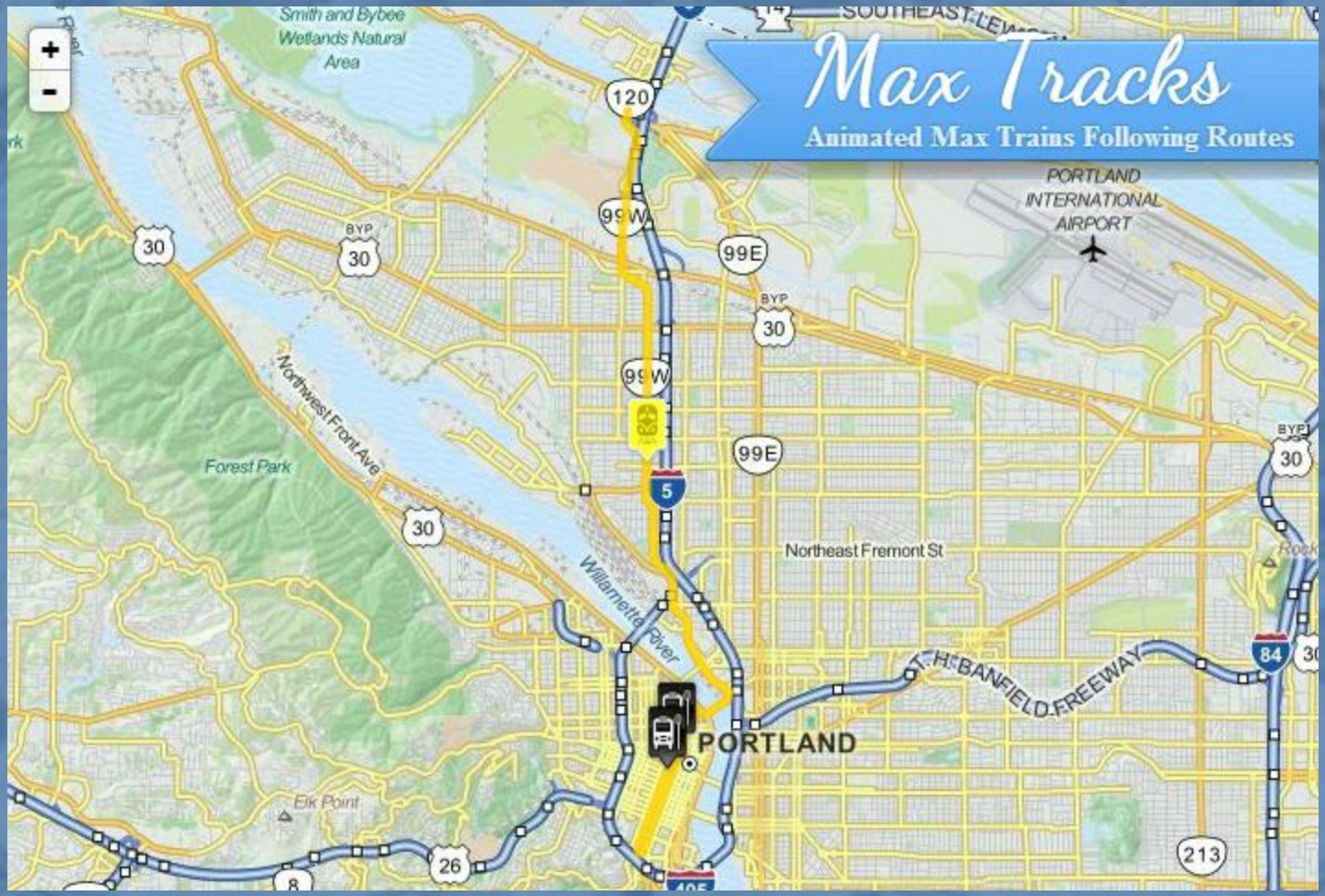
Interactive Animation – location changes – multiple states

- Light rail train line through Portland
- Components: Open Plans Leaflet Animated Marker Plugin; Leaflet map client
- Advantages: track animated, viewer can interact with preprogrammed fields / information from database along the track

- Source: Data points plotted from Google map; Converted to JSON data format; Map Quest slippy map basemap

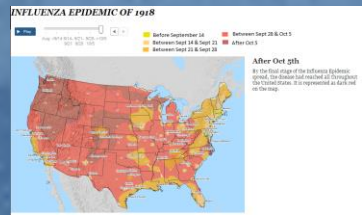
Interactive Animation – location changes – multiple states

- Limitations:
  - Software visualization implies travel but there is only a single rate for a given map.
  - Various browser clients have limitations with the number of vertices/points that can be shown in json format- the more points, the slower the load time

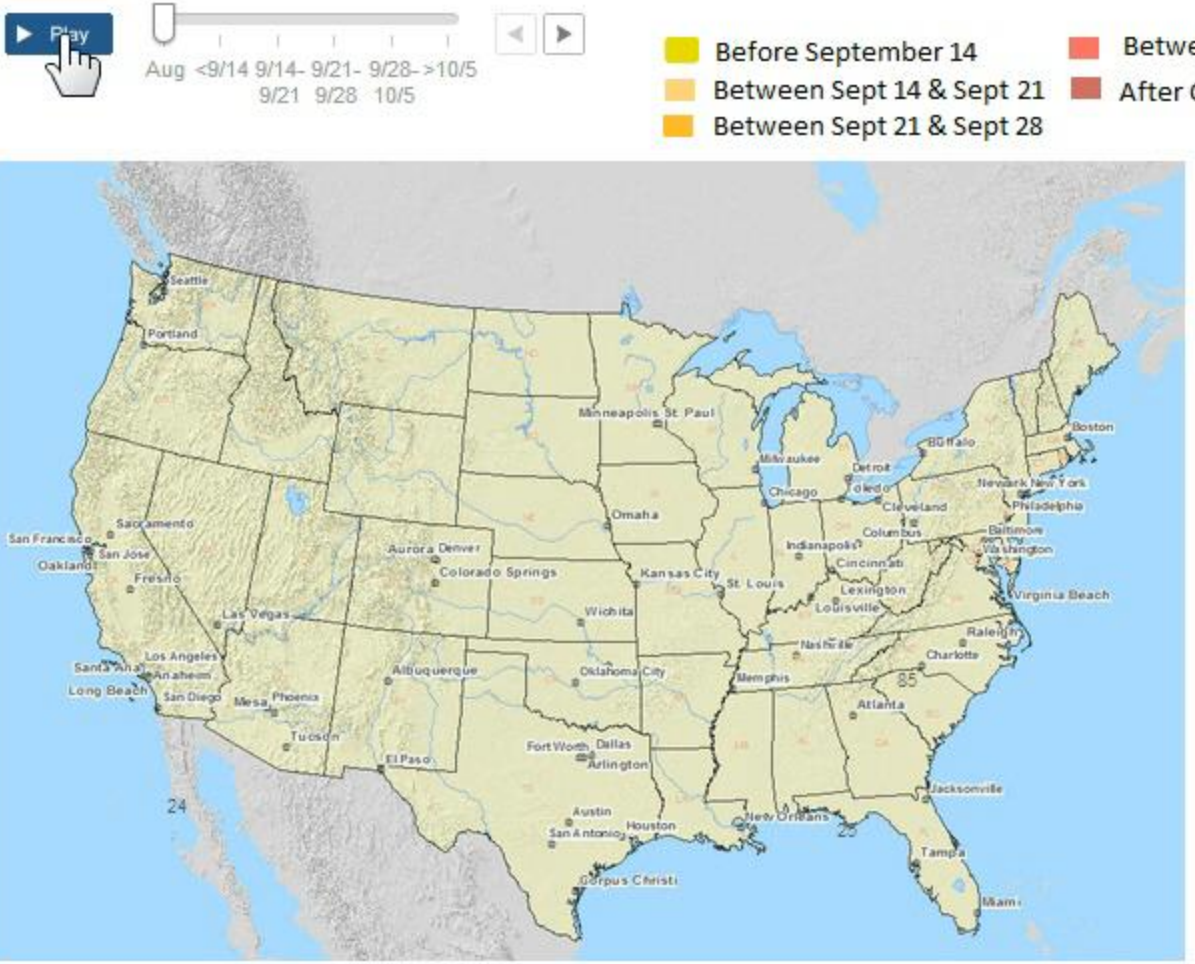

Max Tracks
Animated Max Trains Following Routes
Smith and Bybee Wetlands Natural Area
PORTLAND INTERNATIONAL AIRPORT
Northwest Front Ave
Forest Park
Willamette River
Northeast Fremont St
T.H. BANFIELD FREEWAY
PORTLAND
Elk Point
120
99W
99E
30
BYP
5
84
26
213

Interactive animation – size/shape and location change – rate of spread – qualitative and quantitative change

- Spread of Influenza in the epidemic of 1918
- Components: Jquery Timeline Slider
- Advantages: Viewer can interact with slider to see each time stamp or use the play button for automated play back
- Limitations:
  - No additional attribute information via popups, tables or queries
  - Original data poor quality
- Source: **Office of the Public Health Service Historian , Influenza Epidemic of 1918 Map**
http://www.flu.gov/pandemic/history/1918/life_in_1918/healthservice/



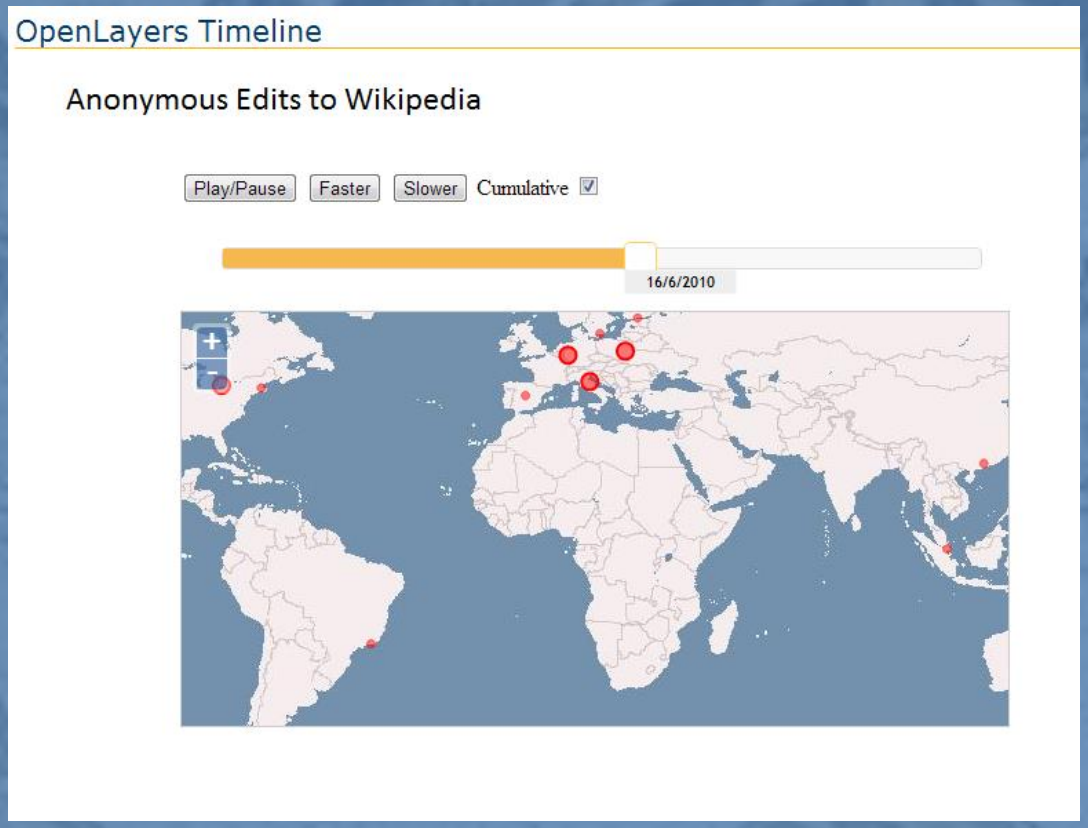
INFLUENZA EPIDEMIC OF 1918



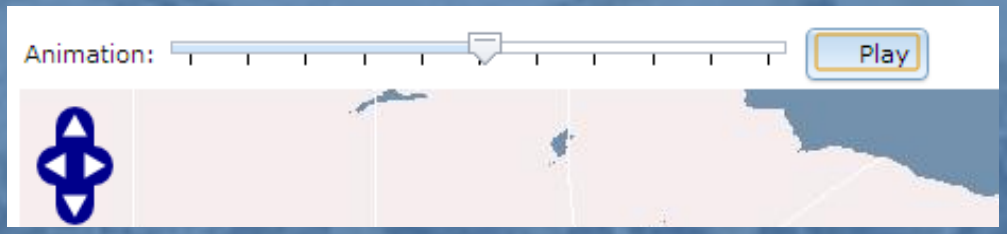
Before the Influenza Epidemic

Chronological map of Influenza epidemic of 1918. Based on preliminary reports from 376 localities. The colors on the map indicate the approximate dates on which the disease spread at each epidemic stage.

Other Timeline Software



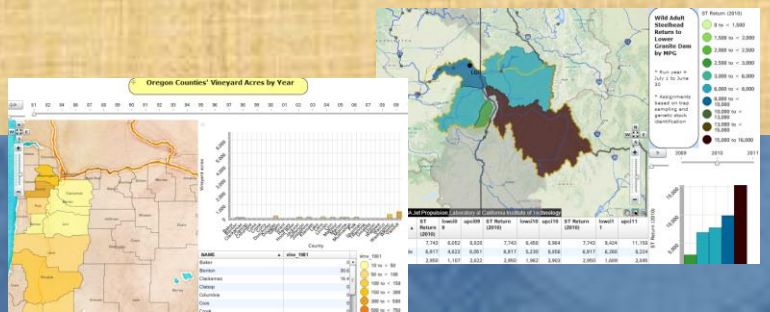
- OpenLayers

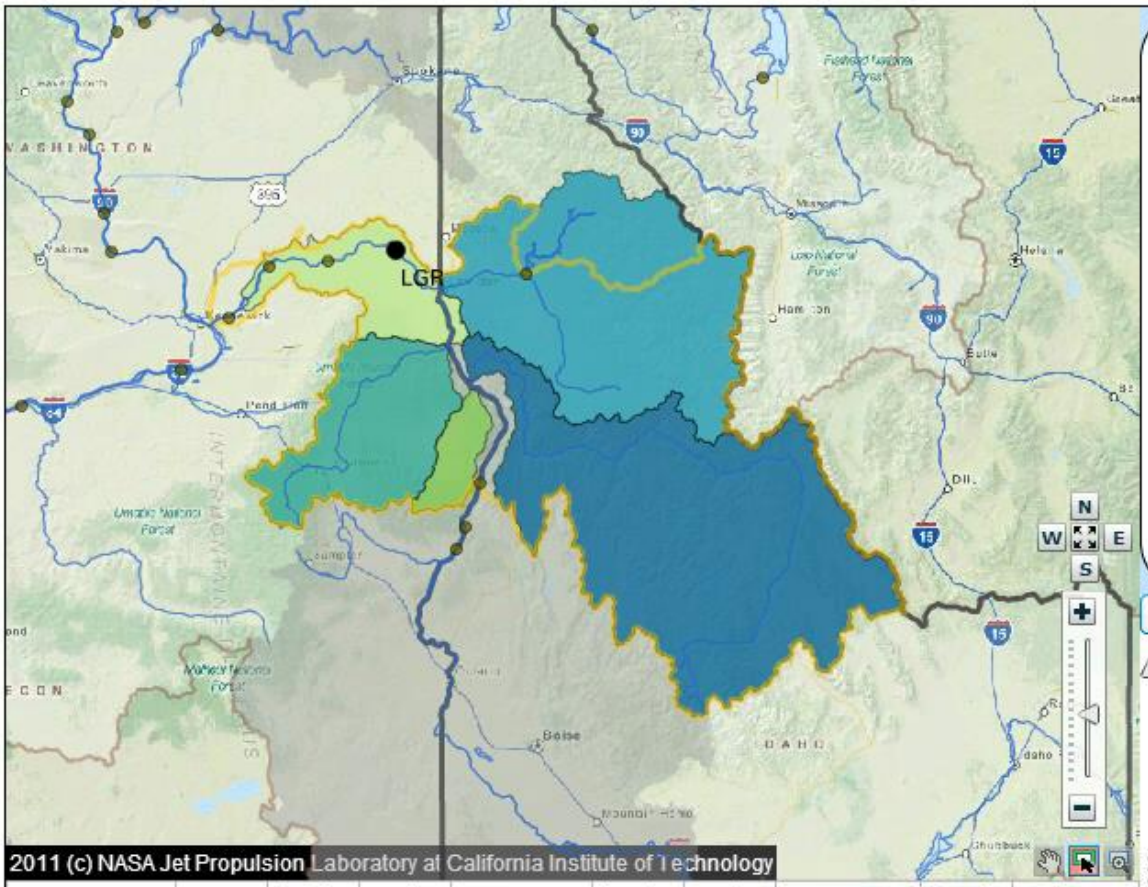


- Dojo and OpenLayers

Interactive animation – spatial presence change – multiple states – qualitative and quantitative change

- Estimated adult wild steelhead return by population group and Oregon counties' vineyard acres by year
- Components: OIC Weave, Adobe Flash, MySQL, Apache Tomcat
- Advantages: viewer can interact with the data and create subsets of the data, viewer can control animation, include graphs/charts linked with map, easy data download
- Limitations: Can be slow loading, Flash required, software can only do choropleth maps
- Source: National Agricultural Statistics Service Oregon County Vineyards, IDFG Adult Steelhead Return to LGR by Major Population Group Estimates MapQuest and Stamen slippy map basemaps





Wild Adult Steelhead Return to Lower Granite Dam by MPG

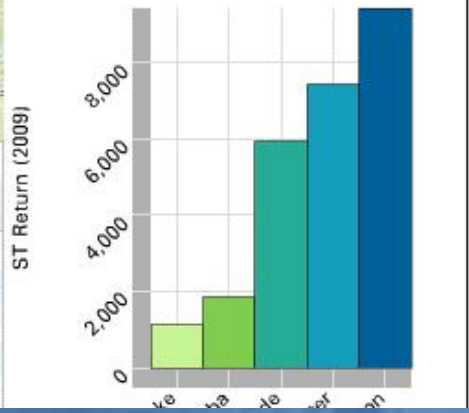
* Run year = July 1 to June 30

* Assignments based on trap sampling and genetic stock identification

ST Return (2009)

- 0 to < 1,500
- 1,500 to < 2,000
- 2,000 to < 2,500
- 2,500 to < 3,000
- 3,000 to < 6,000
- 6,000 to < 8,000
- 8,000 to < 10,000
- 10,000 to < 13,000
- 13,000 to < 15,000
- 15,000 to 16,000

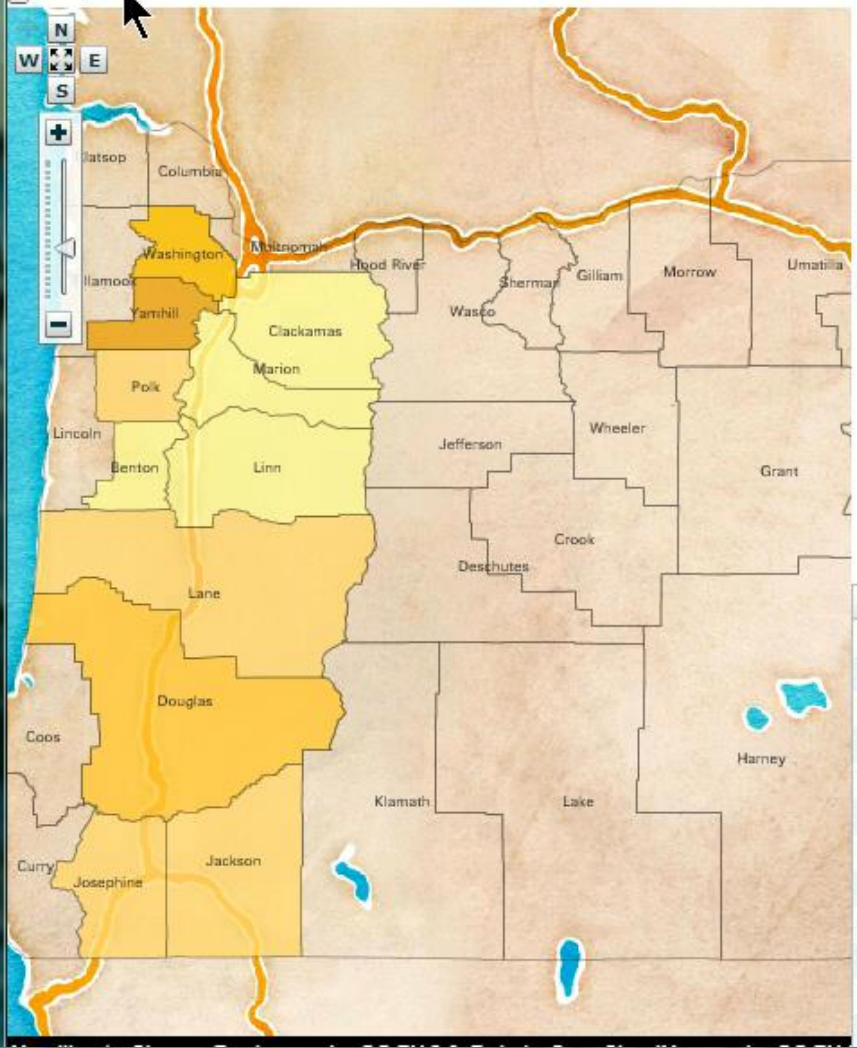
2009 2010 2011

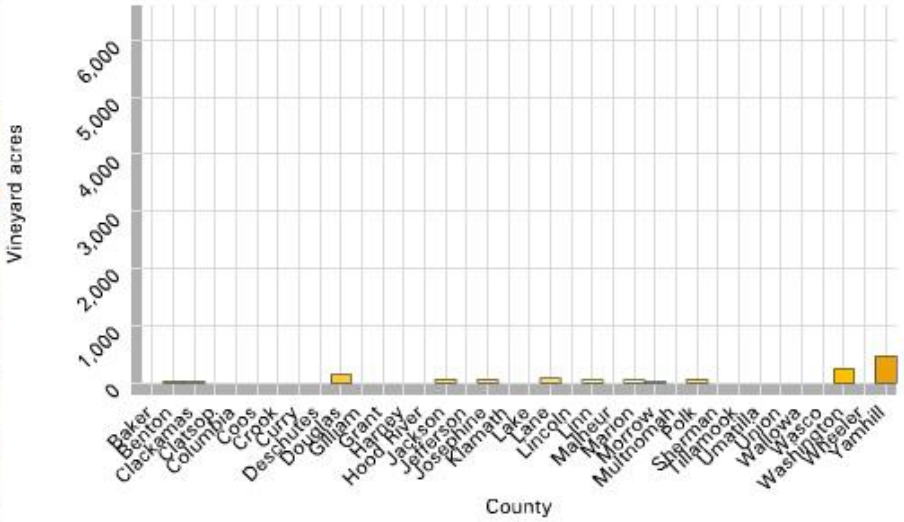


mpgname ▲	ST Return (2009)	lowci09	upci09	ST Return (2009)	lowci10	upci10	ST Return (2009)	lowci11	upci11
Clearwater	7,426	6,052	8,820	7,426	6,458	8,964	7,426	9,424	11,158
Grande Ronde	5,936	4,622	8,051	5,936	5,230	8,856	5,936	6,268	8,224
Imnaha	1,863	1,107	2,622	1,863	1,962	3,903	1,863	1,689	2,845
Lower Snake	1,115	551	1,770	1,115	8,097	12,882	1,115	9,113	11,469
Salmon	9,424	7,810	11,372	9,424	13,249	17,275	9,424	13,381	15,559

Oregon Counties' Vineyard Acres by Year

81 82 84 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10



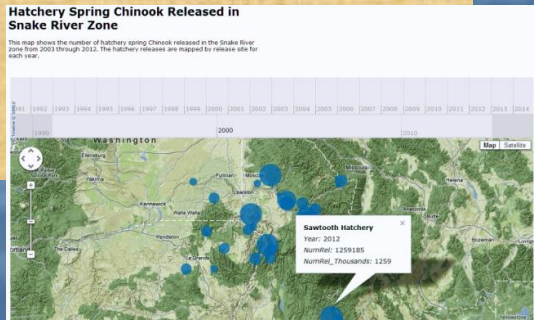


NAME	vine_1981
Baker	0
Benton	30.6
Clackamas	16.4
Clatsop	0
Columbia	0
Coos	0
Crook	0
Curry	0
Deschutes	0
Douglas	132.8
Gilliam	0
Grant	0

vine_1981
- 10 to < 50
- 50 to < 100
- 100 to < 150
- 150 to < 300
- 300 to < 500
- 500 to < 750
- 750 to < 1,000
- 1,000 to < 1,250
- 1,250 to < 1,500
- 1,500 to < 2,500
- 2,500 to 7,000

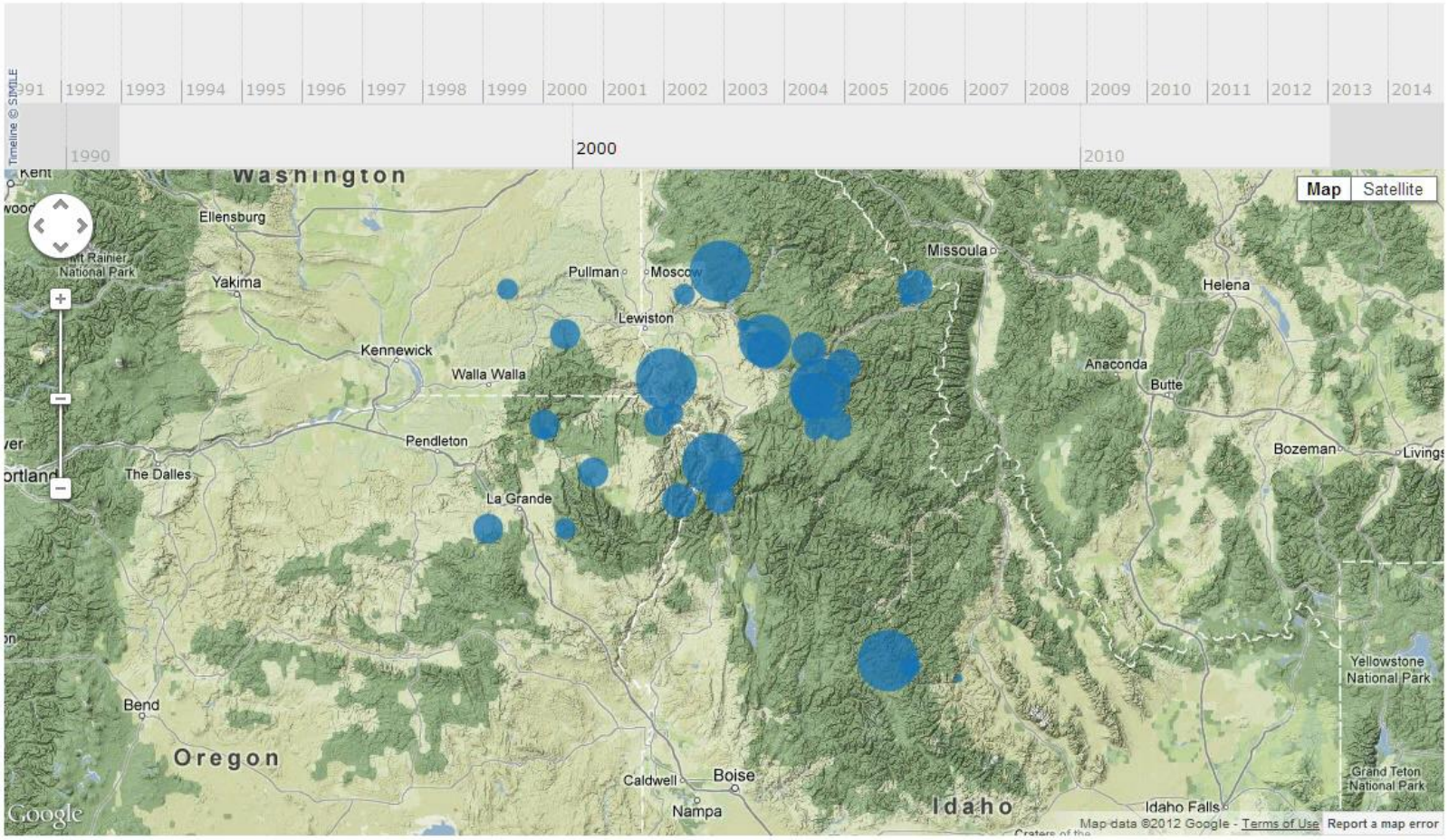
Interactive – presence and location change – multiple states – qualitative and quantitative

- Proportional symbol hatchery spring Chinook released in Snake River 2003 – 2012
- Components: Timemap.js / Heatmap script, OpenLayers client, Google spreadsheet
- Advantages: viewer can interact with site information via popups (can Include graphics and charts), proportional symbol gives viewer a sense of size of release at site, viewer has control over timeline
- Limitations: Various browser clients have limitations with the number or vertices/points that can be shown - the more points, the slower the load time, legend must added
- Data: FPC Hatchery Database Releases, FPC, Google Physical basemap



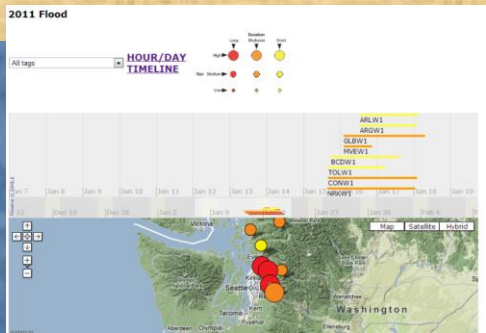
Hatchery Spring Chinook Released in Snake River Zone

This map shows the number of hatchery spring Chinook released in the Snake River zone from 2003 through 2012. The hatchery releases are mapped by release site for each year.



Interactive – presence change – duration – qualitative and quantitative

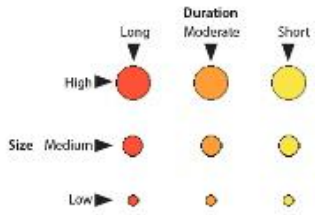
- 2011 Floods
- Components: Timemap.js, Open Layers client
- Advantages: viewer can interact with site information via popups (can Include graphics and charts), proportional symbols, points, polygons, lines or raster, includes plugins for route lines and for polygon boundary change, viewer has control over timeline, viewer can select filtered subsets of data to display
- Limitations: Various browser clients have limitations with the number or vertices/points that can be shown - the more points, the slower the load time, designed symbols and legend outside of Timemap.js
- Source: USGS Flood Data, Google Physical basemap

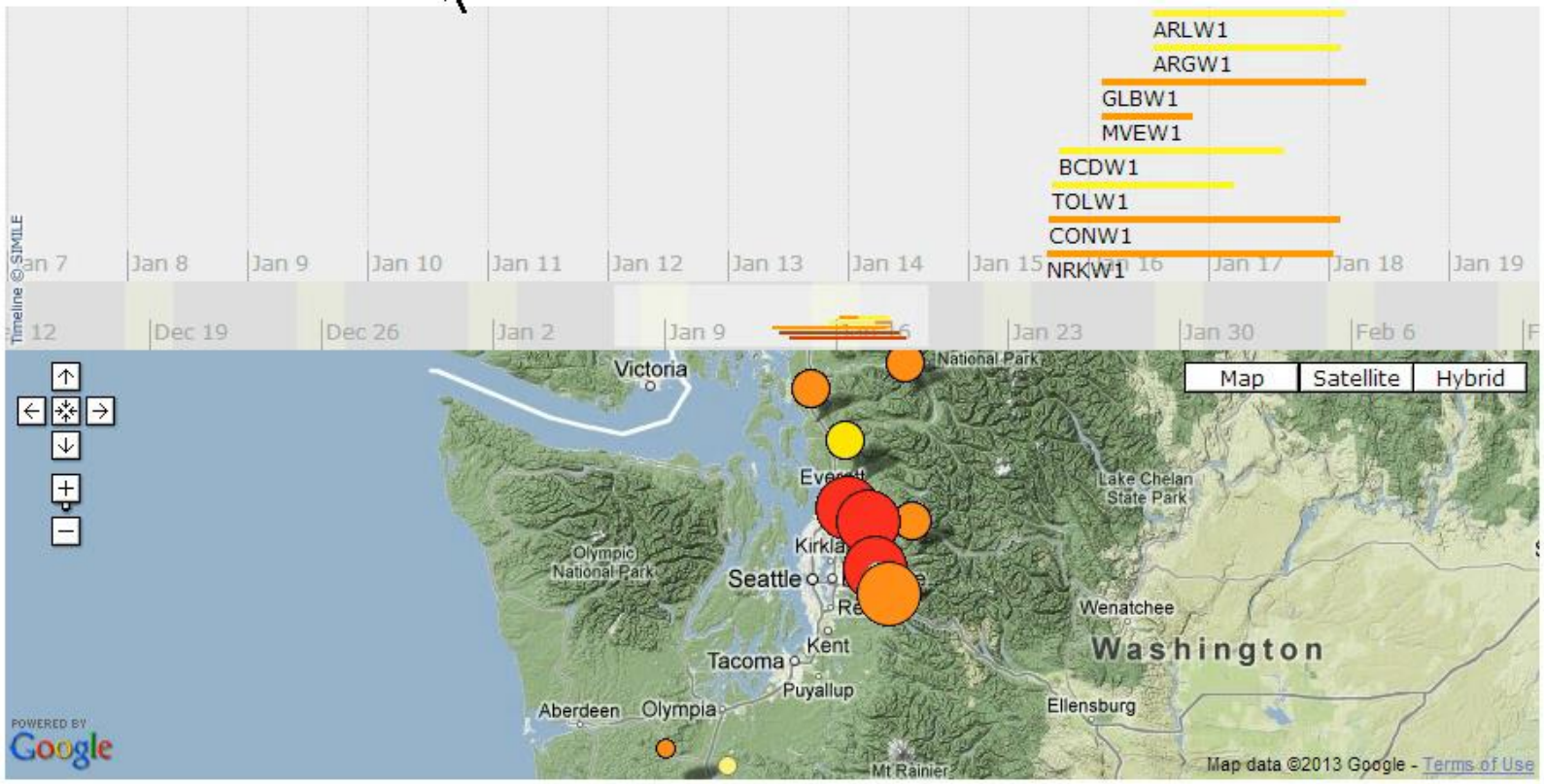


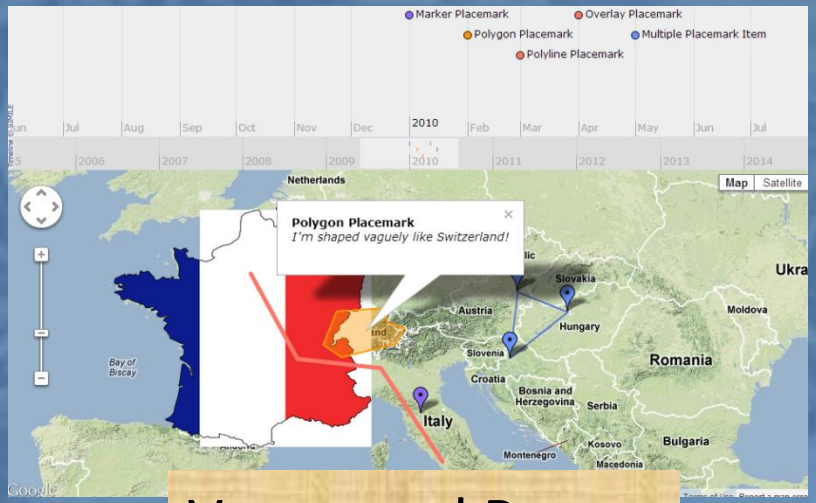
2011 Flood

All tags

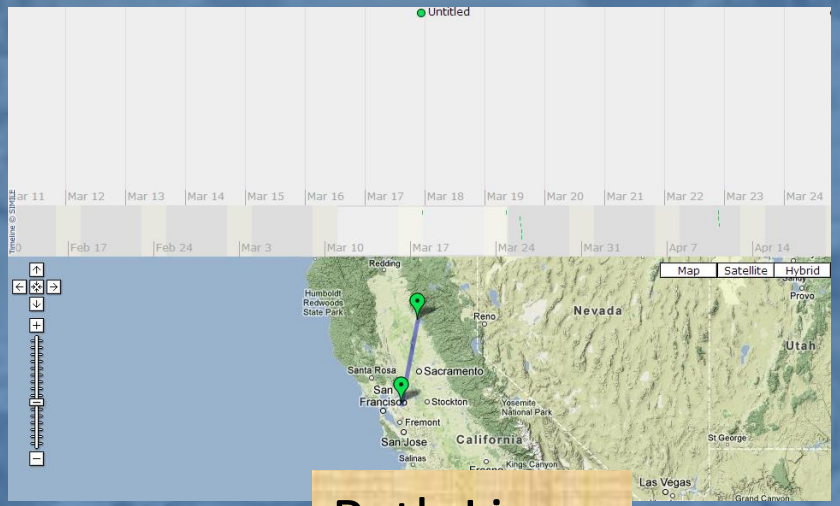
HOUR/DAY TIMELINE



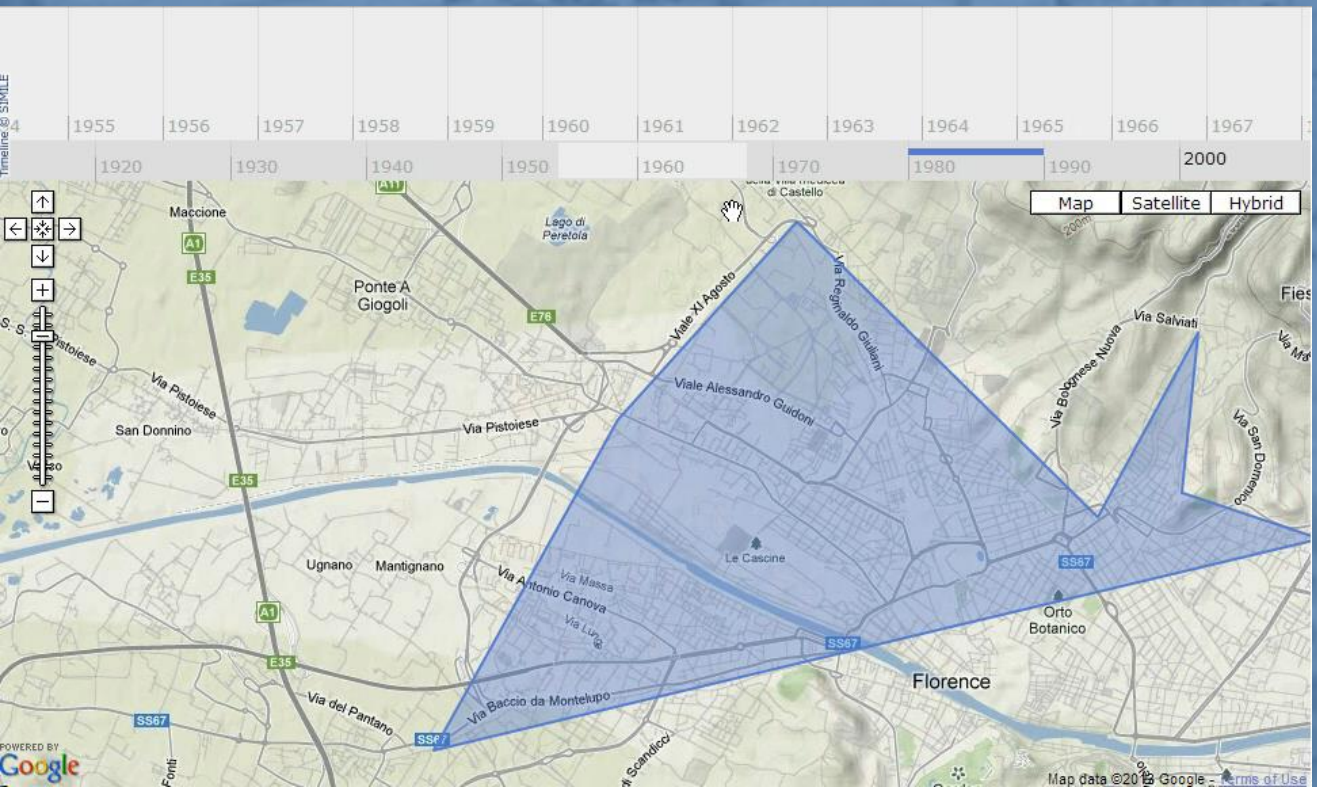




Vector and Raster



Path Lines



Timemap.js and Open Layers

(Got these examples to run on local machine)

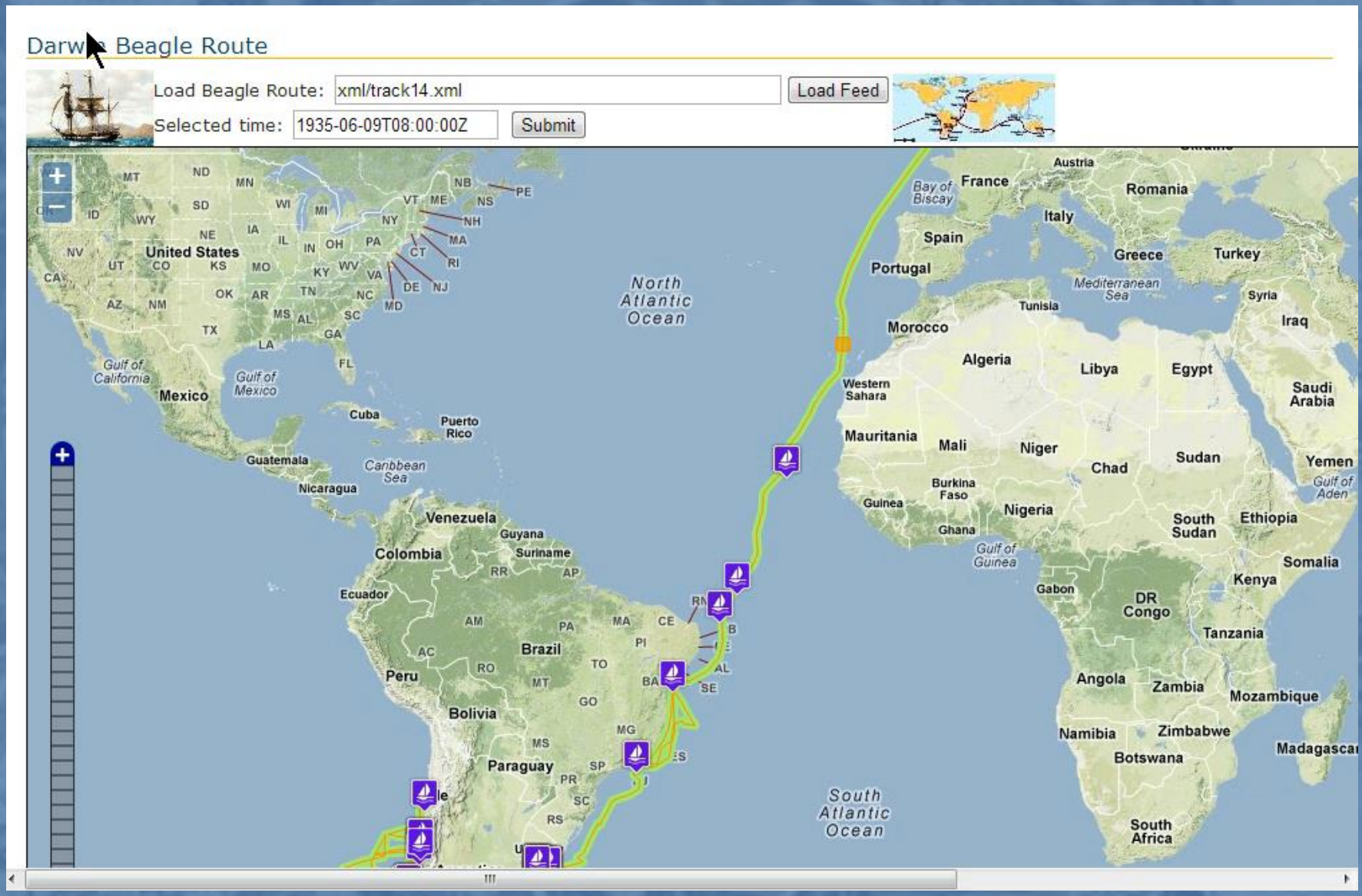
Boundary Changes

Interactive – location change – multiple states – qualitative and quantitative

- Darwin's HMS Beagle route
- Components: OpenLayers Control TimeSliderBar and OpenLayers Layer TimedPointTrack, OpenLayers map client
- Advantages: interactive time slider bar and timed point track, view can interact with preprogrammed information along the track, viewer can highlight specific waypoints along the route

Limitations: Various browser clients have limitations with the number or vertices/points that can be shown. Database requirements for data formatting were incompatible with data for the example. These problems occurred in both GIS animation and data preparation software.

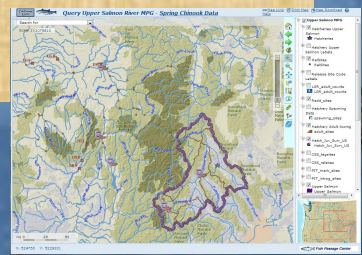
- Source: Darwin HMS Beagle Route from journal entries and Google physical basemap

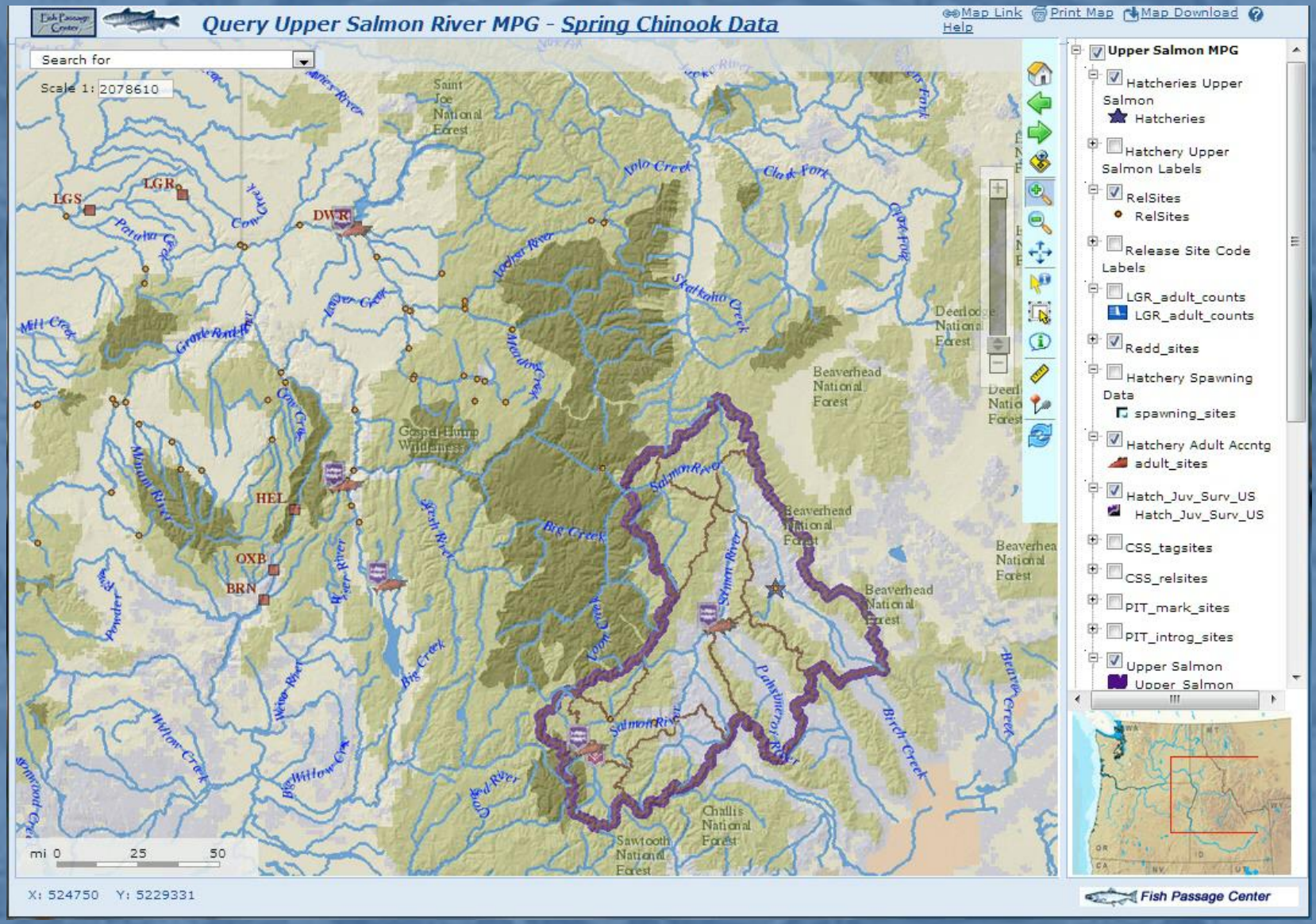

Darwin Beagle Route
Load Beagle Route: xml/track14.xml
Load Feed
Selected time: 1935-06-09T08:00:00Z
Submit
North Atlantic Ocean
South Atlantic Ocean
United States
Mexico
Gulf of California
Gulf of Mexico
Cuba
Puerto Rico
Caribbean Sea
Guatemala
Nicaragua
Venezuela
Guyana
Suriname
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Portugal
Spain
France
Bay of Biscay
Italy
Austria
Romania
Greece
Turkey
Mediterranean Sea
Tunisia
Morocco
Algeria
Libya
Egypt
Western Sahara
Mauritania
Mali
Niger
Chad
Sudan
Nigeria
Burkina Faso
Guinea
Ghana
Gulf of Guinea
Gabon
DR Congo
South Sudan
Ethiopia
Somalia
Kenya
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
South Africa
Madagascar
Saudi Arabia
Yemen
Gulf of Aden
Syria
Iraq

Interactive – all spatial changes – multiple states – qualitative and quantitative

- Redd counts over time
- Components: pMapper, MapServer, Highcharts.js, Dojo.js, Postgressql/PostGis
- Advantages: interactive location map with many layers, viewer can explore site location, fast loading of large datasets, allows downloading of large sets of data quickly, links to interactive graphs of data , It is possible to show data spatially as different layers you can turn off and on, you can program an additional gui control to select for various temporal scales
- Limitations: In this example time data are not displayed spatially, requires data query and additional programming to show data spatially and allow user to query for various time frames

Data: FPC WMS layers and IDFG Redd counts

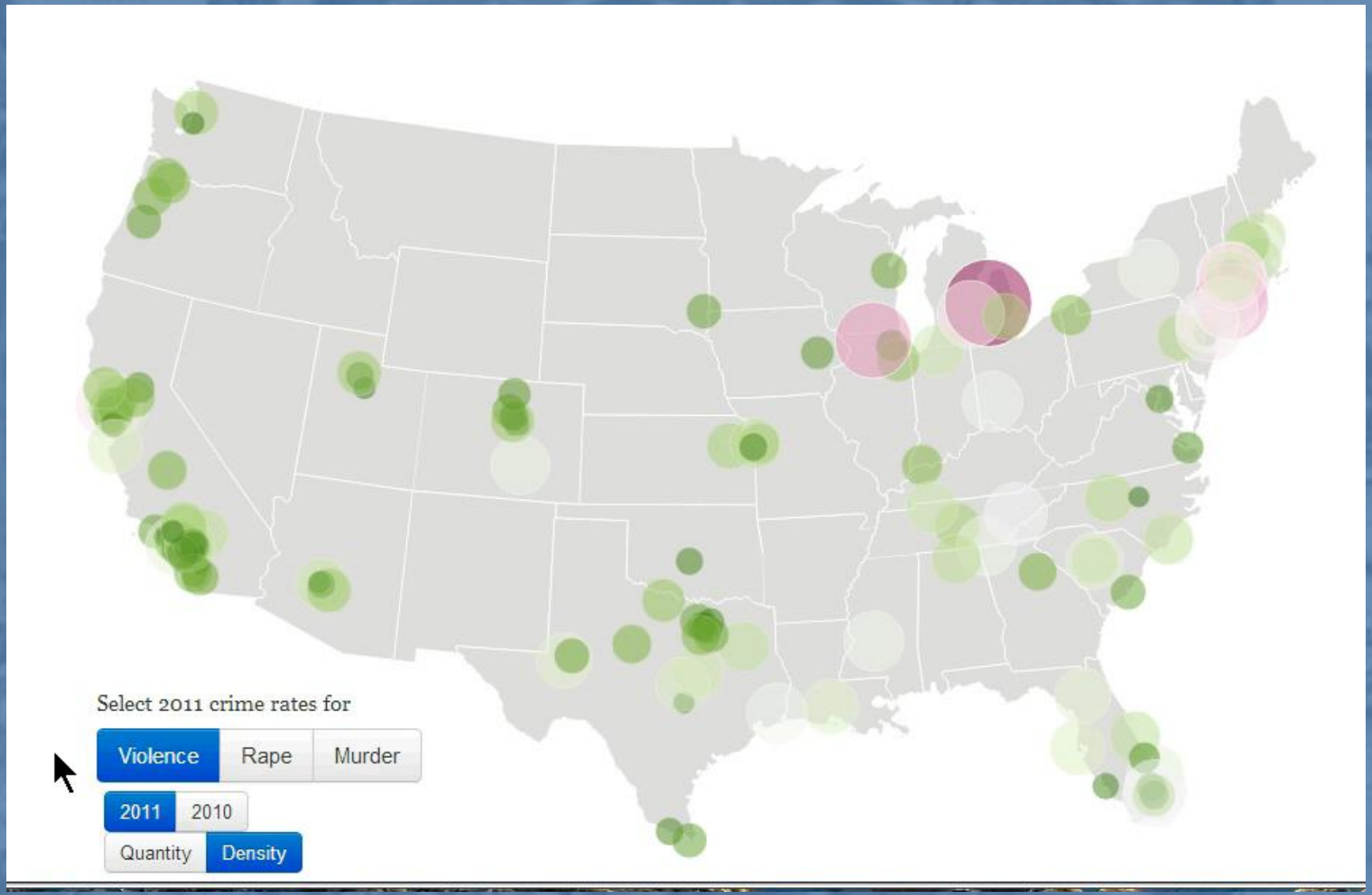



Query Upper Salmon River MPG - Spring Chinook Data
Map Link
Print Map
Map Download
Help
Search for
Scale 1: 2078610
LGS
LGR
DWR
HEL
OXP
BRN
Saint Joe National Forest
Beaverhead National Forest
Deerlodge National Forest
Gospel-Hump Wilderness
Challis National Forest
Sawtooth National Forest
Salmon River
Big Creek
Loon Creek
Upper Salmon
Upper_Salmon
Hatcheries Upper Salmon
Hatcheries
Hatchery Upper Salmon Labels
RelSites
Release Site Code Labels
LGR_adult_counts
Redd_sites
Hatchery Spawning Data
spawning_sites
Hatchery Adult Accntg
adult_sites
Hatch_Juv_Surv_US
CSS_tagsites
CSS_relsites
PIT_mark_sites
PIT_introg_sites
mi 0 25 50
X: 524750 Y: 5229331
Fish Passage Center

Other Examples

Interactive – multiple states – qualitative and quantitative

- US Violent Crimes 2010-2011
- Components: Kartograph.js (example from website)
- Advantages: Beautiful vector interactive maps, fast loading, easy to learn and implement
- Limitations: Only a few online examples, button controls not as easy to use as timesliders


Select 2011 crime rates for
Violence
Rape
Murder
2011
2010
Quantity
Density

Interactive – location changes – multiple states – qualitative and quantitative

- Track of Hurricane Irene with attributes
- Components: JQueryGeo (website example)
- Advantages: Beautiful vector interactive map, excellent vector symbology , easy to learn and develop, can include many tiled basemaps, intuitive controls
- Limitations: Not as versatile as OpenLayers


Hurricane Irene Track Map
Displaying a snapshot of storm data extracted from stormpulse.com
Tiles Courtesy of MapQuest
New York
Indianapolis
Columbus
St. Louis
Kansas City
Louisville
Nashville
Oklahoma City
Memphis
Dallas
Shreveport
Atlanta
Columbia
Charleston
Savannah
Jacksonville
Orlando
St. Petersburg
Cape Coral
Miami
Houston
New Orleans
Mobile
Tallahassee
Raleigh
Wilmington
Bermuda
Sargasso Sea
Gulf of Mexico
Bahamas
Havana
Cuba
Santiago de Cuba
Haiti
Cancun
Merida
Campeche
Veracruz
Brownsville
Corpus Christi
Galveston
Austin
Wichita
Springfield
Knoxville
Augusta
Palm Coast
Santa Clara
Camaguey
Grand Turk
George Town

Interactive animation – location changes – multiple states – qualitative and quantitative

- Track of Hurricane Irene with attribute data
- Components: OpenLayers WMS-t Animated controls and scripts, OpenLayers Map (website example) Client, WMS layers from GeoServer
- Advantages: OpenLayers is very versatile, example includes vector and raster data simultaneously, many online examples, large online community, user can control time steps and can run animation
- Limitations: User controls are not as easy to use when compared to other controls (i.e. dojo or jquery slider)

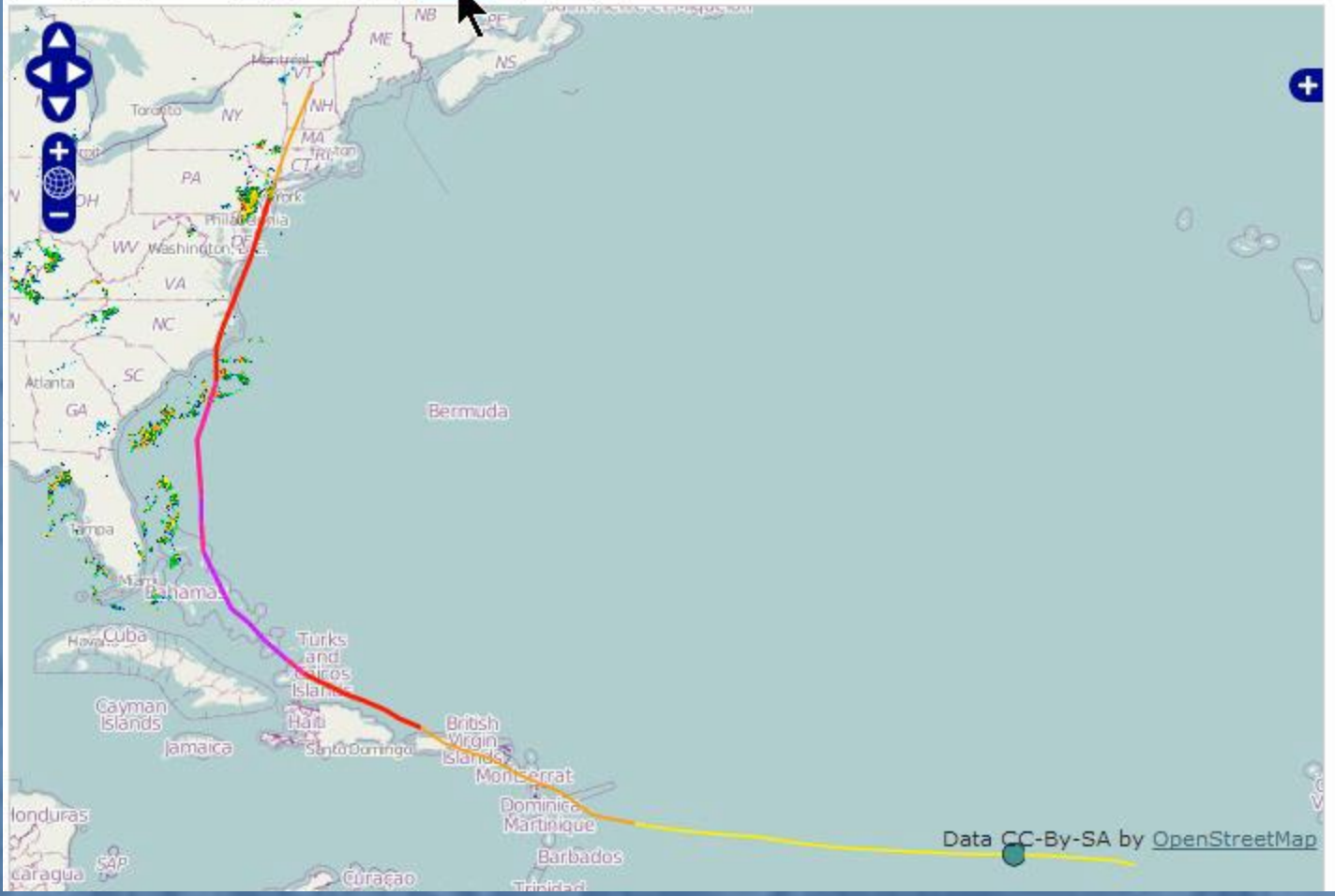
WMS Time Example - Hurricane Irene Aug 2011

Shows the use of the TimeManager control with a single simple WMS-T (time) layer served from Geoserver

Click on the PLAY button to start.

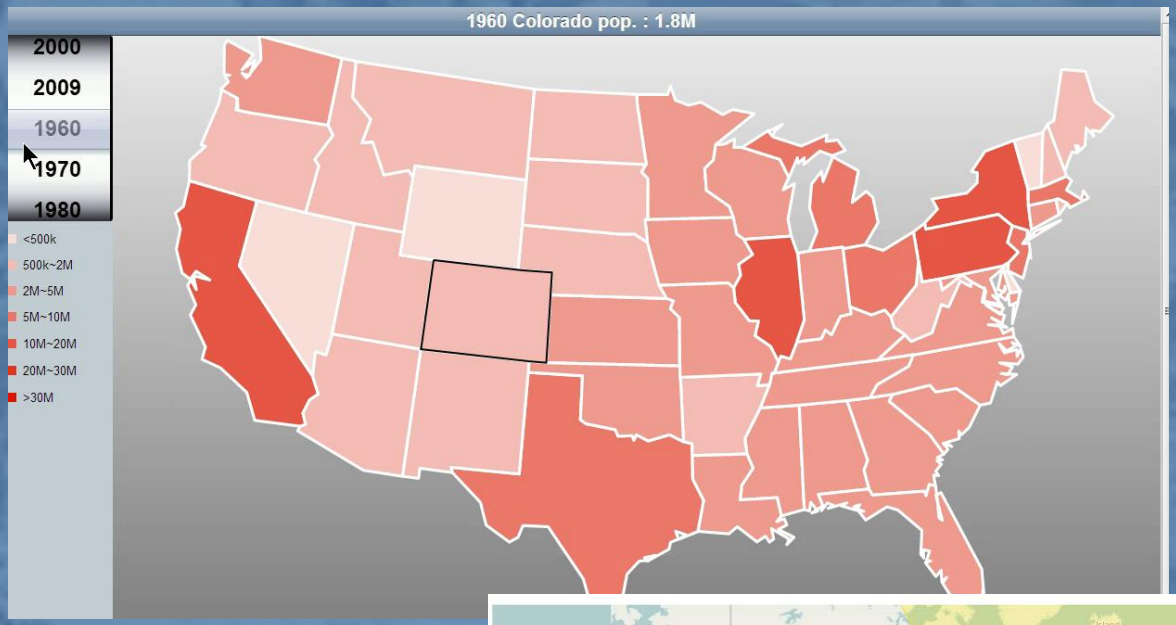
Thu Aug 18 2011 05:00:00 GMT-0700 (Pacific Daylight Time)

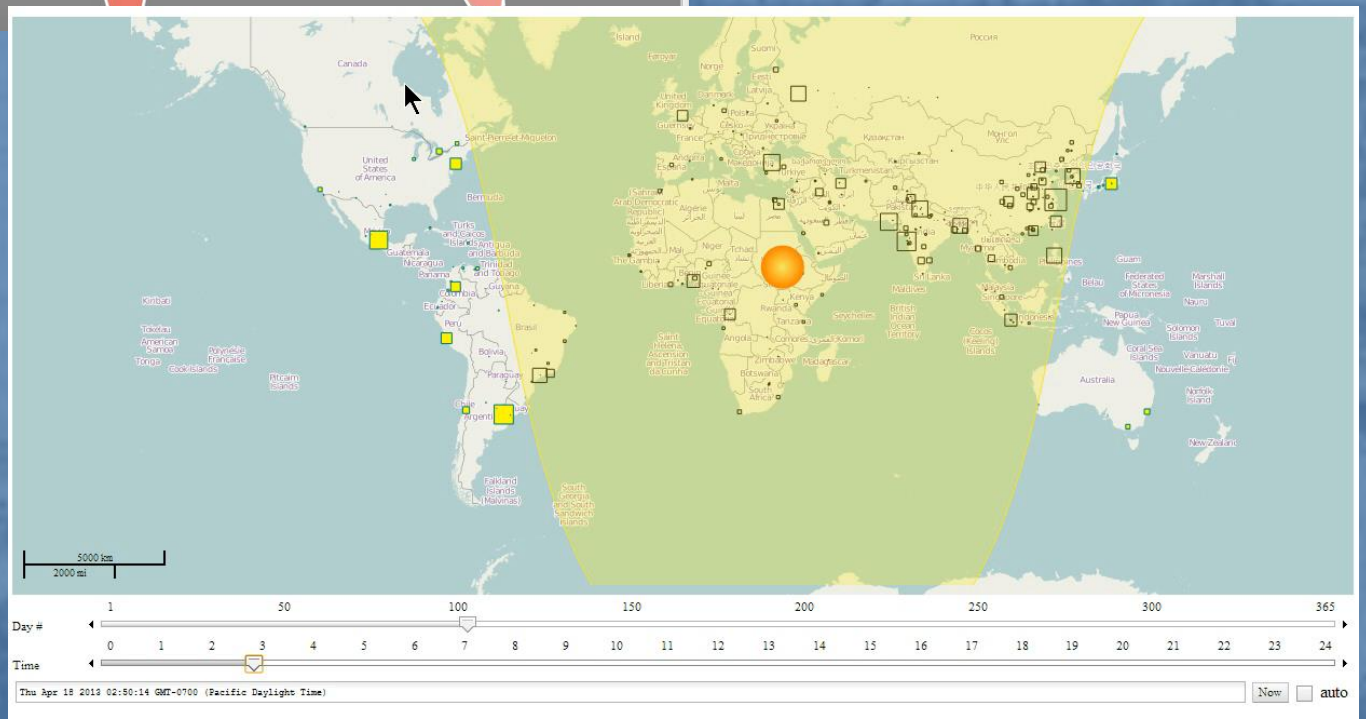
Stop | Reset | Loop | Step | Play



Interactive – location changes – multiple states – qualitative and quantitative

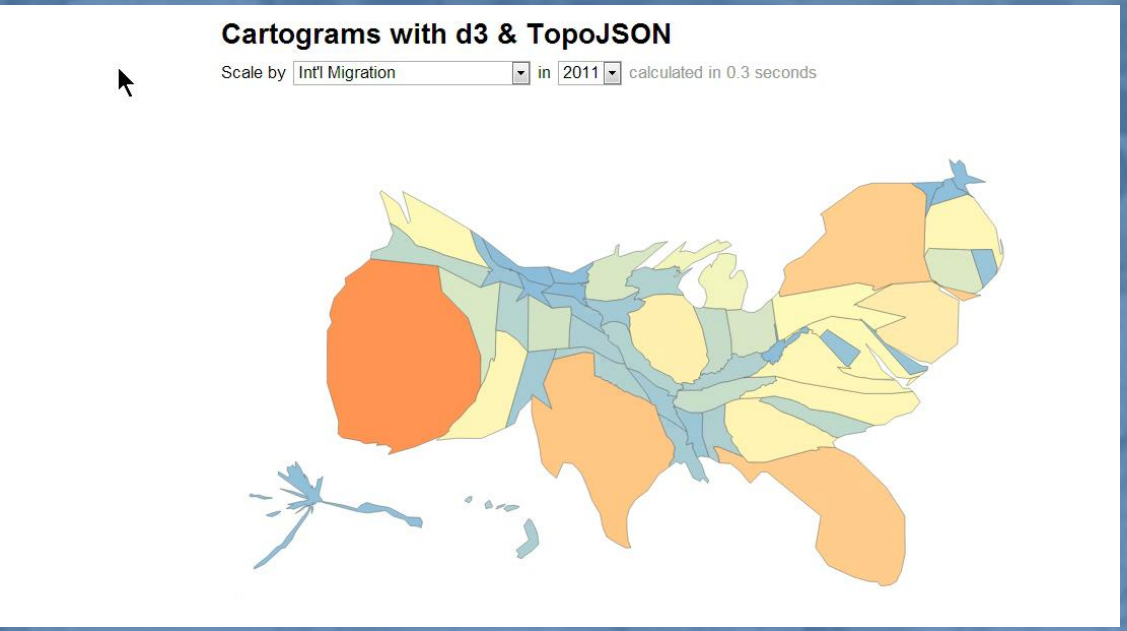
- US Population Data, Sun Animation
- Components: Dojo Toolkit Examples, includes OpenLayers map client (website examples)
- Advantages: Beautiful vector interactive maps and controls, easy to include other libraries with Dojo Toolkit, large online community, many online examples, many widgets or controls available in dojo library including interactive graphs, can include OpenLayers / geoext with Dojo
- Limitations: Somewhat difficult to learn and debug, hierarchy of loading libraries must be in correct order

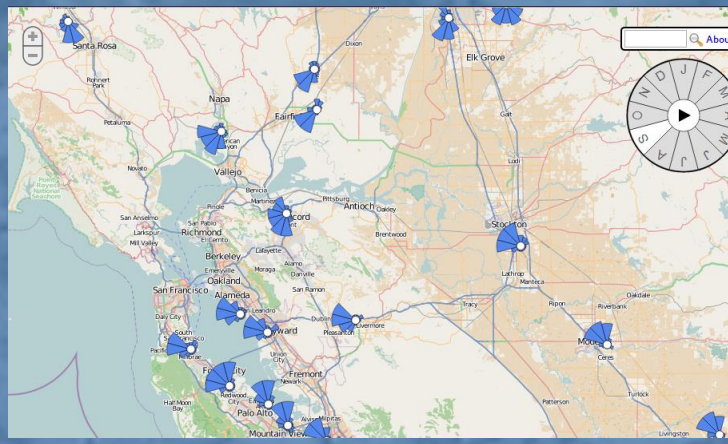

1960 Colorado pop. : 1.8M
2000
2009
1960
1970
1980
<500k
500k~2M
2M~5M
5M~10M
10M~20M
20M~30M
>30M


Canada
United States of America
5000 km
2000 mi
Day #
Time
Thu Apr 18 2013 02:50:14 GMT-0700 (Pacific Daylight Time)
Now
auto

Interactive and animation – all spatial changes – multiple states – qualitative and quantitative

- Wind map, US Cartograms, Wind direction by month
- Components: D3 (website examples)
- Advantages: Beautiful vector animation maps and controls, some limited interaction (dropdown menus choosing variable and time step)
- Limitations: Difficult to learn, no plugins, must develop from base D3 library

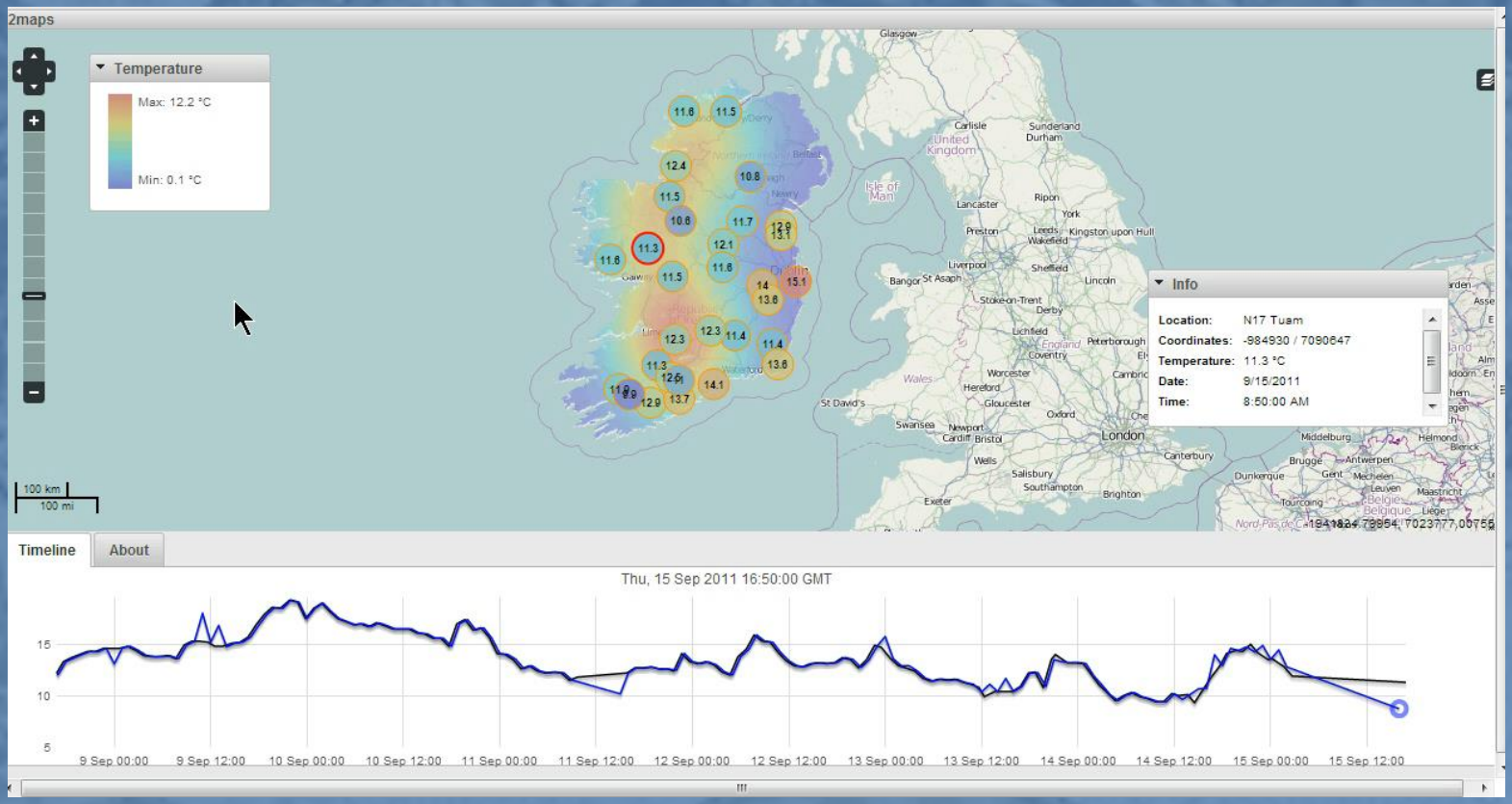

Cartograms with d3 & TopoJSON
Scale by Int'l Migration in 2011 calculated in 0.3 seconds


Santa Rosa
Napa
Vallejo
Richmond
Berkeley
Oakland
San Francisco
Alameda
Hayward
Fremont
Palo Alto
Mountain View
Elk Grove
Antioch
Stockton


wind map
past patterns
<previous
next>
October 29, 2012
8:59 pm EST
(time of forecast download)
top speed: 45.1 mph
average: 9.4 mph
Seattle
San Jose
Denver
Chicago
Columbus
New York
Los Angeles
San Diego
Phoenix
Dallas
Houston
1 mph
3 mph
5 mph
10 mph
15 mph
30 mph

Interactive – all spatial changes – multiple states – qualitative and quantitative

- UK Weather Map
- Components: I2Maps (website example)
- Advantages: Vector and raster data can be shown, locations include popup information and interactive graph for data exploration
- Limitations: Difficult to learn, no plugins, must develop from base i2maps library, slow loading, depending on the amount of data being loaded, not compatible with some non-HTML5 compliant browsers like IE9


2maps
Temperature
Max: 12.2 °C
Min: 0.1 °C
Info
Location: N17 Tuam
Coordinates: -984930 / 7090647
Temperature: 11.3 °C
Date: 9/15/2011
Time: 8:50:00 AM
Timeline
About
Thu, 15 Sep 2011 16:50:00 GMT
15
10
5
9 Sep 00:00
9 Sep 12:00
10 Sep 00:00
10 Sep 12:00
11 Sep 00:00
11 Sep 12:00
12 Sep 00:00
12 Sep 12:00
13 Sep 00:00
13 Sep 12:00
14 Sep 00:00
14 Sep 12:00
15 Sep 00:00
15 Sep 12:00
100 km
100 mi

Issues

Date Issues

- Formatting dates in Excel: it does not recognize dates earlier than 1900. QGIS Time Manager plugin does not recognize dates earlier than 1970.
- Conversion of dates from Julian to Gregorian calendars. Different regions converted at different times.
- Time zones and leap years may affect data usability.
- Date formats are different for every parser. Dates must usually be converted into requested format. (Example: 12/31/1967 vs. 1967-12-31)

Data issues

- Getting data in a format that the software stack can use. Some of formats used were Google spreadsheet, Geojson, Postgres/PostGIS WMS from GeoServer/MapServer, text file, raster image (GeoTiff), ESRI shapefile, Excel spreadsheet, CSV, SVG.
- Big data (many date/time states) can significantly slow down processing and map rendering. A one-minute animation at 20 frames per second has 1200 images. (other online mapping options may assist with this i.e. cartodb).
- Parser misses some characters that prevent data from being read correctly.
- Small, almost invisible characters will stop the program. Text must be squeaky clean. (Degree symbol, extra spaces, etc.)

More Data Issues

- Missing intervals in some data sequences.
- How to code non-data areas so they'll draw up as something.
- Sometimes geographic images are not georeferenced (GOES).
- Just because you have coordinates in a track, does not mean that it won't make an impossible path (Ex. ship coordinates crossing land.)

Map Design

- Some software components do not have included legends, scales or other title/notes/text. You'll have to program them.
- Some freely available map backgrounds (Google Maps, OpenStreetMap) can't be projected on-the-fly in the software. (Must be tiled externally.) Or you use Geographic or Mercator for map display.

Boundary Issues

- Boundaries from different sources may not line up, can create slivers and gaps.
- Boundaries of administrative/political entities change over time, again you have different polygons, and sliver/gaps. (Census).
- Areal unit change problems. Attribute values are associated with original areal unit (county boundaries). Areal units change over time which requires a method (i.e. weighted average) to estimate the changes.

Data classification issues

- Data described in two eras may have different parameters, level of detail, inclusion or elimination, accuracy/precision.
- One example is habitat inventories. Categories are dependent on the purpose of the inventory and the researchers. Between two temporal states new habitat classes may be identified and old classes need to be reconciled to newer ones.
- Habitat studies are constrained also by the varying boundaries of old and new classes.
- A second example is the decadal Census information. Decade by decade, the information collected has changed with new categories added, old ones removed or definitions altered, so that comparing two states can be difficult.

Lessons Learned

- Open source is, for the most part, a competent and even excellent substitute for commercial software. It's getting better all the time.
- Finding the software takes some searching and testing. Start at SourceForge.net and GitHub.com.
- The online community of users is the best part. Someone, somewhere has done it and posted the solution. (Or at least a hint.)
- Documentation is highly variable.

Lessons Learned (contd)

- Processes you're familiar with will take much longer (at least the first time).
- There is no 'all-in-one' package; you will cobble together a collection of components.
- You will be programming or rewriting existing programs at some point.
- Data processing will take the majority of your time---but you knew that anyway.

Spatial-temporal mapping framework

Presentation	Spatial	Temporal	Attribute
Static	Size/shape	State	Qualitative
Animation	Location	Rate	Quantitative
Interactive	Presence/ absence	Duration	
		Interval	

- The software we evaluated is capable of visualizing almost all of the categories in our spatial-temporal framework (exception interval data)
- Did not evaluate interval data or variable movement data (i.e. animal motion)

Fear no Open Source
Just dive in.